In the Specification

Kindly replace the paragraph bridging pages 5 and 6 with the following:

It ~~is an object of the present invention~~ would therefore be advantageous to provide a high tensile strength hot-rolled steel sheet having superior strain aging hardenability which overcomes the limitations of the conventional techniques described above, which has high formability and stable quality characteristics, and in which satisfactory strength is obtained when the steel sheet is formed into automotive components, thus greatly contributing to lightening of automobile bodies. It ~~is another object of the present invention~~ would also be advantageous to provide a method for industrially producing such a steel sheet at low costs and without disturbing the shape thereof.

Kindly amend the section heading on page 6, line 4 from:

~~Disclosure of the Invention~~ to

Summary

Kindly replace the paragraph bridging pages 6 and 7 with the following:

~~In order to solve the problems described above, the present inventors have~~ We produced various steel sheets by changing compositions and production methods and have conducted many material evaluation tests. As a result, it has been found that an improvement in formability and an increase in strength after formation are easily made compatible with each other by using N, which has not been used positively in the field where high workability is required, as a strengthening element, and by effectively using a large strain aging hardening phenomenon exhibited by the action of N as the strengthening element. In order to effectively use the strain aging hardening phenomenon by N, the strain aging hardening phenomenon by N must be

effectively combined with paint baking conditions for automobiles and heat-treating conditions after formation. The present inventors have found that it is effective to adjust the microstructure and the amount of dissolved N in a steel sheet within predetermined ranges by optimizing the hot rolling conditions. It has also been found that in order to stably cause the strain aging hardening phenomenon by N, it is particularly important to control the Al content according to the N content in terms of compositions.

Kindly replace the paragraph bridging pages 7 and 8 with the following:

In general, in order to evaluate bake hardenability, a tensile test is used. Since large variations in strength occurred when the conventional steel sheets were subjected to plastic deformation under the actual press conditions, the conventional steel sheets could not be applied to components in which high reliability was required even if the conventional steel sheets were evaluated as having desired bake hardenability in the tensile test. In contrast, variations in strength are small when the steel sheet ~~of the present invention~~ disclosed herein is subjected to plastic deformation under the actual press conditions. Furthermore, the steel sheet ~~of the present invention~~ disclosed herein has a higher evaluation of bake hardenability according to the tensile test compare to the conventional steel sheets. It has been found that stable component strength characteristics are obtained by using the disclosed steel sheet ~~of the present invention~~.

Kindly replace the paragraph on page 8, lines 3 to 13 with the following:

The thin hot-rolled steel sheet used for automobile bodies must have very accurate shape and dimension. It has been found that accuracy of shape and dimension is greatly improved by employing a continuous rolling technique which has recently been put into practical use in the hot rolling process for producing the disclosed steel sheet ~~of the present invention~~. Furthermore,

it has been found that variations in material properties can be greatly decreased by partially heating or cooling the rolled material so that the temperature profiles in the width direction and in the lengthwise direction become uniform.

Kindly replace the paragraph on page 8, lines 14 and 15 with the following:

~~The present~~ Various aspects of the invention ~~has~~ have been achieved based on the findings described above and are summarized as follows.

Kindly replace the first paragraph on page 14 with the following:

FIG. 1 is a graph which shows BH (an increase in deformation stress) with respect to examples of ~~the present invention~~ disclosed steel sheets and comparative examples.

Kindly replace the paragraph on page 14, lines 4 to 6 with the following:

FIG. 2 is a graph which shows ΔTS (an increase in tensile strength) with respect to examples of ~~the present invention~~ disclosed steel sheets and comparative examples.

Kindly amend the section heading on page 14, line 8 from:

~~Best Mode for Carrying Out the Invention~~ to

Detailed Description

Kindly replace the paragraph on page 14, lines 9 to 12 with the following:

First, the chemical compositions of disclosed ~~steel~~ steels ~~in the present invention~~ will be described. The content (%) of each constituent element is shown in percent by mass.

Kindly replace the paragraph bridging pages 19 and 20 with the following:

Al is added to steel as a deoxidizing element, which is effective in improving the cleanness of the steel, and Al is also preferably added to the steel in order to achieve texture refinement. However, if the Al content is excessive, the following problems arise. (1) The

surface properties of steel sheets are degraded. (2) The amount of dissolved N, which is important ~~in the present invention~~ is decreased. (3) Even if dissolved N is ensured, if the Al content exceeds 0.02%, variations in strain aging hardenability due to the change in production conditions are increased. Therefore, the Al content is limited to 0.02% or less. Additionally, in view of material stability, the Al content is more preferably set at 0.001% to 0.016%.

Kindly replace the paragraph on page 20, lines 6 to 21 with the following:

N is the most important constituent element in the present invention. That is, by the addition of an appropriate amount of N to control the production conditions, it is possible to secure a necessary and sufficient amount of N in the dissolved state in the mother plate (as hot rolled). Thereby, the effect of an increase in strength (YS, TS) due to solid-solution strengthening and strain aging hardening is satisfactorily exhibited, and it is possible to stably satisfy the mechanical property conditions of the steel sheet of the present invention, i.e., TS of 440 MPa or more, BH of 80 MPa or more, and ΔTS of 40 MPa or more. N also decreases the Ar_3 transformation temperature. Since it is possible to prevent a thin steel sheet, whose temperature is easily decreased during hot rolling, from being rolled at a temperature lower than the Ar_3 transformation temperature, N is effective in stabilizing operation.

Kindly replace the paragraph on page 21, lines 9 to 15 with the following:

Even if N is added, if the N content is in the disclosed range ~~of the present invention~~, there is substantially no increase in deformation resistance at elevated temperatures during the production of steel sheets. It has been found that use of strengthening due to N is significantly advantageous to the production of high tensile strength thin hot-rolled steel sheets.

Kindly replace the paragraph bridging pages 21 and 22 with the following:

In order to ensure sufficient strength in the mother plate and to exhibit satisfactory strain aging hardenability due to N, i.e., to set the BH at 80 MPa or more and the ΔTS at 40 MPa or more, 0.0010% or more of N in the dissolved state (hereinafter referred to as "dissolved N") must be present in steel. Herein, the amount of dissolved N is found by subtracting the amount of precipitated N from the total amount of N in steel. As a method for extracting precipitated N, i.e., as a method for dissolving ferrite, an acidolysis, a halogen process, or an electrolytic process may be used. As a result of comparative study among these methods for dissolving ferrite, ~~the present inventors have~~ we found that the electrolytic process is most superior. In the electrolytic process, only ferrite can be stably dissolved without decomposing significantly unstable precipitates, such as carbides and nitrides. Accordingly, ~~in the present invention~~, precipitated N is extracted by dissolving ferrite using the electrolytic process. As an electrolytic solution, an acetylacetone-based solution is used, and electrolysis is performed at a constant potential. The residue extracted by the electrolytic process is chemically analyzed to find the N amount in the residue, which is defined as the amount of precipitated N.

Kindly replace the paragraph bridging pages 22 and 23 with the following:

As described above, in order to keep 0.0010% or more of dissolved N stably without being affected by the production conditions, the amount of Al, which is an element for strongly fixing N, must be limited to 0.02% or less. As a result of searching for the conditions in which the amount of dissolved N after hot rolling is 0.0010% or more with respect to steels in which the combination of the N amount and the Al amount is widely changed within the compositional range ~~of the present invention~~, it has been found that the ratio N/Al must be 0.3 or more.

Furthermore, cooling conditions and the coiling temperature condition after finish-rolling must be set in the ranges described below. Therefore, the Al amount is limited N/0.3 or less.

Kindly replace the first paragraph on page 25 with the following:

When Nb and V are added ~~in the present invention~~, preferably, 0.1% in total of at least one or more than 0.02% to 0.1% of Nb and more than 0.02% to 0.1% of V is contained.

Kindly replace the paragraph on page 25, lines 4 to 17 with the following:

Nb and V are important constituent elements ~~in the present invention~~. By adding appropriate amounts of Nb and V and by controlling the production conditions as described below, it is possible to form an appropriate amount of significantly fine carbonitrides, and desired strength is ensured and the yield ratio can be greatly increased. Thereby, fatigue resistance and impact resistance are remarkably improved. Furthermore, the fine carbonitrides of Nb and V improve the strain aging hardenability and contribute to refinement and uniformization of the ferrite grain size. If the content of Nb or V (i.e., the concentration of the additive constituent in steel) is 0.02% or less, the effect thereof is small, and therefore, the content of Nb or V is set at more than 0.02%.

Kindly replace the paragraph on page 28, lines 3 to 9 with the following:

~~In the present invention, the~~ The average grain size is determined by the value which is larger when compared between the value measured by mensuration according to ASTM based on a photograph of the sectional structure and the nominal grain size measured by an intercept method (for example, refer to "Thermal Treatment" 24 (1984) 334 by Umemoto, et al.).

Kindly replace the paragraph bridging pages 28 and 29 with the following:

When the martensite phase (M phase) is contained in the structure ~~in the present invention~~, the areal rate of the M phase is preferably 5% or more. The M phase contained in the structure at the areal rate of 5% or more is effective in the present invention. Thereby, the steel sheet has satisfactory ductility in spite of high strength and high BH and ΔTS. If the areal rate of the M phase is less than 5%, the effect thereof is not obtained sufficiently. Due to the presence of the martensite phase at the areal rate of 5% or more, in addition to the improvement in ductility, the yield ratio = YS/TS is decreased, and the shape fixability improving effect is remarkably exhibited particularly when working is performed in the minute strain range.

Kindly replace the paragraph on page 29, lines 13 to 19 with the following:

In view of ductility and the low yield ratio, the areal rate of the M phase is preferably less than 35%, and more preferably, 7% to 20%. In such a case, in the steel sheet ~~of the present invention~~, in addition to ferrite and martensite, the bainite phase, the pearlite phase, etc. may be contained in the structure if the areal rate thereof is several percent.

Kindly replace the paragraph on page 30, lines 2 to 10 with the following:

~~In the present invention, when~~ <u>When</u> Nb and V are added, the average grain size of the precipitate comprising Nb or V carbonitrides is preferably 0.05 μm or less. In order for the carbonitrides of Nb or V to increase strength and to improve strain aging hardenability, the carbonitrides must be precipitated finely. If the average grain size of the carbonitrides is coarser than 0.05 μm, the effects thereof are not exhibited. Therefore, the average grain size of the carbonitrides is set at 0.05 μm or less.

Kindly replace the paragraph on page 31, lines 3 to 5 with the following:

~~In the present invention, as~~ As described above, "having superior strain aging hardenability" means to have the following characteristics:

Kindly replace the paragraph bridging pages 31 and 32 with the following:

When strain aging hardenability is defined, a prestrain (predeformation) is an important factor. ~~The present inventors~~ We have studied the influence of the prestrain on strain aging hardenability, assuming the deformation mode applied to steel sheets used for automobiles. As a result, it has been found that (1) the deformation stress in the deformation mode described above can be substantially integrated into a uniaxial stress (tensile strain) except for extremely deep drawing; (2) in a real component, the uniaxial stress generally exceeds 5%; and (3) component strength (strength of a real component) well corresponds to the strength obtained after strain aging treatment with a prestrain of 5% is performed. Based on the knowledge described above, the predeformation for the strain aging treatment is defined as a tensile strain of 5%.

Kindly replace the paragraph bridging pages 32 and 33 with the following:

Specifically, ~~in the steel sheet of the present invention,~~ the lower limit of the heating temperature in which hardening is noticeable after preformation is approximately 100°C. On the other hand, if the heating temperature exceeds 300°C, hardening hits the peak, and if the heating temperature is 400°C or more, a tendency toward slightly softening appears, and also thermal strain and temper color become conspicuous. As for the retention time, hardening is satisfactorily achieved if the retention time is set at approximately 30 seconds at a heating temperature of approximately 200°C. In order to achieve the larger amount of hardening and stable hardening, the retention time is preferably set at 60 seconds or more. However, even if

retention is performed for more than 20 minutes, no further hardening is achieved, and production efficiency is reduced, resulting in no practical benefits.

Kindly replace the paragraph bridging pages 33 and 34 with the following:

For the reasons described above, ~~when the steel sheet of the present invention is used,~~ after working is performed, preferably, the heating temperature is set at 100 to 300°C and the retention time is set at 30 seconds to 20 minutes as the aging treatment conditions. ~~In the present invention, even~~ Even under the aging conditions of low-temperature heating and short-time retention in which sufficient hardening is not achieved in the conventional paint baking type steel sheet, a large amount of hardening can be obtained. Additionally, the method for heating is not specifically limited, and in addition to atmospheric heating using a furnace which is employed for general paint baking, induction heating, heating by non-oxidizing flame, laser beam, or plasma, or the like may be preferably used.

Kindly replace the paragraph on page 34, lines 3 to 17 with the following:

Automobile components must have strength which can cope with complex stress loading from outside. Therefore, it is important for the material steel sheet to have a strength characteristic in the small strain range as well as a strength characteristic in the large strain range. From this viewpoint, ~~the present inventors~~ We have limited BH to 80 MPa or more and TS to 40 MPa or more with respect to the steel sheet of the present invention to be used as material for automobile components. More preferably, BH is set at 100MPa or more and ΔTS is set at 50 MPa or more. It is understood that the above limitations define BH and ΔTS under the conditions of aging treatment of 170°C X 20 minutes after a prestrain of 5% is applied. BH and

ΔTS may be increased also by setting the heating temperature higher and/or by setting the retention time longer.

Kindly replace the paragraph bridging pages 34 and 35 with the following:

In the steel sheet ~~of the present invention~~, even if accelerated aging by heating (artificial heating) is not performed after forming and working, only by leaving the steel sheet at room temperature, an increase in strength corresponding to at least approximately 40% of full aging is expected. Moreover, on the other hand, in the state in which forming and working are not performed, even if the steel sheet is left at room temperature for a long time, aging degradation, i.e., a phenomenon in which YS increases and El (elongation) decreases, does not occur, which is a superior characteristic not observed in the known art.

Kindly replace the paragraph on page 35, lines 4 to 11 with the following:

When the thickness of the produced steel sheet exceeds 4.0 mm, the advantages of the present invention are lost because even the conventional steel sheet having large deformation resistance at elevated temperatures can be easily hot-rolled and because steel sheets having a thickness of more then 4.0 mm are not substantially used for automobiles. Therefore, the steel sheet ~~of the present invention~~ preferably has a thickness of 4.0 mm or less.

Kindly replace the paragraph on page 35, lines 20 and 21 with the following:

Next, the method for producing the steel sheet ~~of the present invention~~ will be described.

Kindly replace the paragraph bridging pages 35 and 36 with the following:

The steel sheet ~~of the present invention~~ is produced basically by a hot-rolling process in which a steel slab having the composition within the disclosed ranges ~~of the present invention~~ is heated, the steel slab is rough-rolled to form a sheet bar, the sheet bar is finish-rolled, and coiling

is performed after cooling. Although the slab is preferably formed by continuous casting in order to avoid macroscopic segregation of constituents, the slab may be formed by an ingot-making method, or a thin slab continuous casting method. Instead of the ordinary process in which the produced slab is cooled to room temperature and heating is performed again, an energy-saving process, such as a process in which a hot slab without cooling is inserted into a furnace or a direct rolling process in which a produced slab is directly rolled after slight retention of heat, may be used. In particular, in order to efficiently secure N in the dissolved state, direct rolling is one of the effective techniques.

Kindly replace the paragraph bridging pages 36 and 37 with the following:

After rough-rolling is performed, the sheet bar is subjected to finish-rolling. ~~In the present invention, finish~~ Finish-rolling is preferably performed continuously by joining consecutive sheet bars to each other between rough-rolling and finish-rolling. As the joining means, fusion-pressure welding, laser beam welding, electron beam welding, or the like may be appropriately used.

Kindly replace the paragraph bridging pages 37 and 38 with the following:

~~In the present invention, preferably~~ Preferably, at least one of a sheet bar edge heater for heating a widthwise end of the sheet bar and a sheet bar heater for heating a lengthwise end of the sheet bar is used between the steps of rough-rolling and finish-rolling so that the temperature profiles in the width direction and in the lengthwise direction becomes uniform. Thereby, the variations in material properties within the steel sheet can be further decreased. A sheet bar edge heater or sheet bar heater of induction heating type is preferably used.

Kindly replace the paragraph on page 40, lines 3 to 13 with the following:

~~In the present invention, with~~ With respect to the cooling pattern when the M phase is contained in the structure at the areal rate of 5% or more, cooling may be performed continuously as is usually done, or in order to control the γ to α transformation during cooling and to achieve the phase separation in the structure advantageously, it is also effective to perform slow cooling (interruption of rapid cooling) for approximately 1 to 5 seconds at a rate of 10°C/s or less in the temperature range of 700 to 800°C. However, after the slow cooling, rapid cooling must be performed again at a rate of 20°C/s or more.

Kindly replace the paragraph bridging pages 40 and 41 with the following:

~~In the present invention, when~~ When the M phase is contained in the structure at the areal rate of 5% or more, the coiling temperature is preferably set to 450°C or less. The strength of the steel sheet increases as the coiling temperature decreases. At a CT of 450°C or less, the texture is refined and the areal rate of the M phase reaches 5% or more, and thereby the target TS of 440 MPa or more is achieved. Therefore, the CT is set at 450°C or less. Furthermore, in order to obtain the M phase stably, 40°C/s or more is preferable. Additionally, if the CT is less than 100°C , the shape of the steel sheet is easily disturbed and the possibility of causing problems in practical use increases. Therefore, the CT is preferably 100°C or more. In view of material uniformity, the CT is preferably 150°C or more.

Kindly replace the paragraph on page 41, lines 14 to 23 with the following:

~~In the present invention, when~~ When Nb and V are contained, the coiling temperature is preferably set at 550 to 650°C. In such a case, if the coiling temperature is higher than 650°C, since carbonitrides of Nb and V are coarsened, it becomes difficult to adjust the grain size thereof

to 0.05 μm or less and the strength of the steel sheet is also decreased. If the CT is lower than 550°C, since precipitation of carbonitrides of Nb and V is suppressed, the predetermined amount of carbonitrides cannot be secured. Therefore, the CT is set at 550 to 650°C.

Kindly replace the paragraph bridging pages 41 and 42 with the following:

Furthermore, ~~in the present invention,~~ preferably, working (working after hot-rolling) is performed by at least one of skin pass rolling and leveling with an elongation of 1.5% to 10% after coiling is performed. Additionally, the elongation of skin pass rolling is equal to the reduction rate of skin pass rolling.

Kindly replace the paragraph on page 42, lines 5 to 20 with the following:

Skin pass rolling and leveling are usually performed to adjust roughness and to correct shape. ~~In the present invention, in~~ In addition thereto, skin pass rolling and leveling are effective in increasing and stabilizing the BH and ΔTS. Such an effect is remarkably caused at an elongation of 1.5% or more. However, if the elongation exceeds 10%, ductility is decreased. Therefore, working after hot-rolling is preferably performed with an elongation of 1.5% to 10%. Additionally, although the working mode is different between skin pass rolling and leveling (the former is rolling and the latter is repeated bending and stretching), the effects of the elongation on the strain aging hardenability of the steel sheet ~~of the present invention~~ in both workings are substantially the same. ~~In the present invention, acid~~ Acid pickling may be performed before or after the working after hot-rolling.

Kindly replace the paragraph on page 47, lines 15 to 20 with the following:

The results thereof are shown in Tables 11 and 12. In the examples ~~of the present invention~~, significantly higher BH and ΔTS were observed compared to the comparative

examples, and the improvements in fatigue resistance and impact resistance due to the strain aging treatment were larger compared to the comparative examples.

Kindly replace the paragraph on page 48, lines 6 to 11 with the following:

With respect to the steel sheet No. A (~~steel of the present invention~~ inventive steels) and the steel sheet No. O (comparative steel) shown in Tables 11 and 12, BH and ΔTS were investigated with a prestrain of 5% under the aging treatment conditions shown in Table 13. Table 13 also shows the results thereof.

Kindly replace the paragraph on page 48, lines 12 to 15 with the following:

As is obvious from Table 13, the steel No. A ~~of the present invention~~ exhibits high values of BH and ΔTS even under the relatively low-temperature, short-time aging treatment conditions of 100°C x 30 seconds.

Kindly replace the paragraph on page 50, lines 5 to 11 with the following:

The results thereof are shown in Table 16. In the examples ~~of the present invention~~, the values of BH and ΔTS are large, and also high fatigue resistance and impact resistance are exhibited. The values of En/TS and σw/TS are also large, and superior fatigue resistance and impact resistance are exhibited compared to the comparative steels having the same strength level.

Kindly replace the paragraph bridging pages 50 and 51 with the following:

With respect to the high tensile strength hot-rolled steel sheet ~~of the present invention~~, since dissolved N is appropriately used, the strength of the mother plate with a TS of 440 MPa or more is exhibited, and superior strain aging hardenability with a BH of 80 MPa or more and a ΔTS of 40 MPa or more is exhibited after strain aging treatment is performed. The same

characteristics are exhibited after plating is performed, and moreover, it is possible to perform hot-rolling inexpensively without disturbing the shape. The thickness of the steel sheet used for automotive components can be decreased, for example, from approximately 2.0 mm to approximately 1.6 mm, thus greatly contributing to lightening of automobile bodies.